

(Serious) Gaming and Brain-Computer Interfacing: New Developments

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Entertainment vs Serious games?

- Entertainment games
 - Play, challenges, cooperation, competition, communication, decision-making, skills, learning, ...
- Edutainment games
 - Explicit learning goals
- Serious games
 - Game designed for a primary purpose other than pure entertainment
 - Simulations of realistic situations, training, safe failures

Thirty Minutes Of Gaming A Day Makes Your Brain Bigger: Science

Could 30 minutes a day keep the neurologist away? posted on October 31, 2013



Joseph Berntstein BuzzFeed StaffFor years, proponents of video games as more than idle time-wasters have argued that the act of playing games can in and of itself boost brain function. A study published yesterday by researchers from the Max Planck Institute for Human Development, in the prestigious journal *Nature*, may be the best proof yet that regularly playing video games can actually make your brain more powerful.

It's certainly the most visceral. The study, titled "Playing Super Mario induces structural brain plasticity; gray matter changes resulting from training with a commercial video game," found that people who played at least 30 minutes of *Mario 64* every day for two months actually grew significant amounts of new gray matter in three areas of the brain correlated with spatial navigation, strategic planning, working memory, and motor performance.

Computer-based

- Computer-based simulations
 - Fantasy worlds
 - Real worlds
- From videogames to physical environments equipped with sensors and actuators to immersive virtual reality environments

What can BCI add?

- Entertainment, Edutainment, Serious Games
 - Balancing challenges and skills
 - Measuring attention, engagement, frustration, focus, workload, ...
 - Game design
 - Real-time game adaptation
 - Introducing new challenges in game control
 - New interaction modalities -> new game concepts
- But, seriously

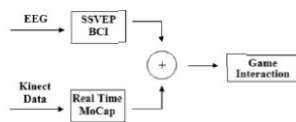
Medical EEG-based Serious Games

- Neurofeedback games
 - enhancement of attention and cognitive skills
 - therapies for psychological disorders: ADHD, ASD, GAD, SUD,
- BCI games for rehabilitation exercises
 - retain motor control
 - Example: Brain-Kinect interface

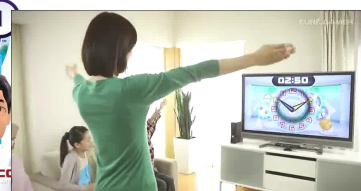
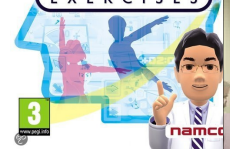
Brain Kinect Rehabilitation



BKI: Brain Kinect Interface, a new hybrid BCI for rehabilitation



Commercial Brain-Body games



- Brain trainers
 - Left Brain Right Brain
- Body and brain
 - Kinect + Xbox

Serious Games?

- Observation 1: Many authors use the term 'serious game' rather than 'game', while
- Observation 2: BCI does not always add
 Serious game: Rome Reborn
 - Teaching history
 - Navigate avatar through ancient Rome using BCI
 - Control a serious game. Impact on learning? Not investigated.

Developments in BCI Games

And some History

BCI for Games

'One Trick' Only Games

- Pong
- Tetris
- Pinball
- Brain ball
- Mind
- Balance
-
- MindFlex

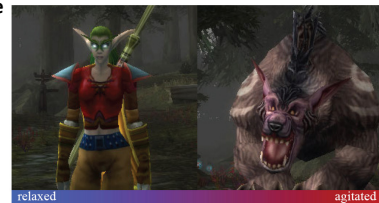


BCI for Games

Multimodal Game

- Becoming angry/acting angry
- Becoming relaxed/acting relaxed

Embed BCI in an existing commercial game



BCI for Games



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BCI for Games

20 July 2009:
Visit to Blizzard
Entertainment
HQ, Irvine, CA



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BCI for Games

**Multimodal &
Multiplayer**



Social interaction
between players

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BCI for Games



**Multimodal, Multiplayer,
but**

- Physiologically Modulated Videogame (FPS)
- Controller: Wii Zapper
- Competition/Collaboration

NASA: interpersonal interactions may be mixes of competition and cooperation for simulation training

BCI for Games

BrainPong

- Multiplayer



BrainBall

- Competition, Collaboration
- Fusion
- **MultiBrain**

Back in Time

MultiBrain

Early History

Early History: Rosenboom

Mike Douglas
Show, 1972



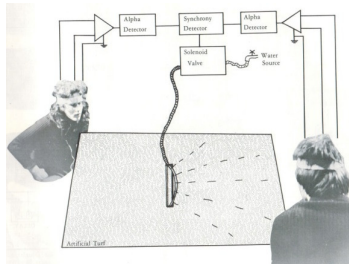
Early History: Sobell

Brainwave Drawing Game
Nina Sobell, 1972-1975



Superimpose visualized brain wave synchronicity on the image of the two participants (Lissajous visualization)

Early History: Humbert



- Alpha Garden
- Jacqueline Humbert, April 1973

A synchrony detector triggers the opening of a solenoid valve, thereby controlling the flow of water through a garden hose and lawn sprinkler system

More Recent Examples

Competition/Collaboration
Integration of brain activities

MultiBrain BCI: Observations



Mind the Sheep!

- No fusion
- MultiBrain?
- Social
- Strategy
- Feedback
- Collaboration
- Competition

MultiBrain BCI: Observations



BrainPong

- Competition
- No fusion
- MultiBrain?
- No competition about control

MultiBrain BCI: Observations



Brainball

- Competition
- Collaboration
- Fusion
- Feedback
- MultiBrain

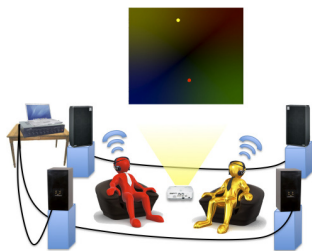
MultiBrain BCI: Observations



BrainArena

- Motor imagery
- MultiBrain
- Fusion
- Competitive/collaborative mode
- Joint visual feedback

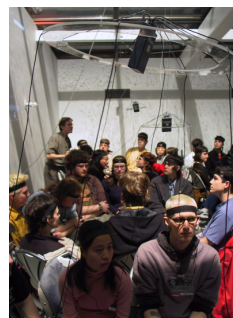
MultiBrain BCI: Observations



MoodMixer

- Sonification
- Visualization
- Relaxation/Focus
- Multibrain

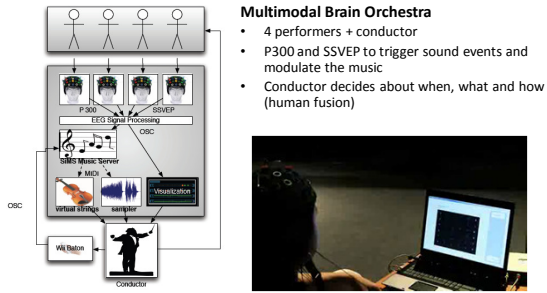
MultiBrain BCI: Observations



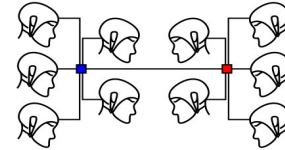
DECONcert1 (2003)

- 48 people's EEG signals
- Collected, averaged
- Alpha synchronization
- Control a soundscape
- Collaborative feedback

MultiBrain BCI: Observations



MultiBrain BCI: Observations



Two competing teams using BCI: blue team (left) versus red team (right).

MultiBrain BCI: Observations

Serious and Entertainment Games

Team Tasks & Team Performance

- Assess team performance, rearrange tasks
- On-line collaborative decision making in a target decision task
- Team collaboration in movement planning

Research efforts for each of these tasks can be found in the BCI literature

With a Little Help from ...

Stylish Devices ...



Emotiv Epoc, Emotiv Insight, Google Glasses, Ocular Rift, ...

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More Stylish Devices ...



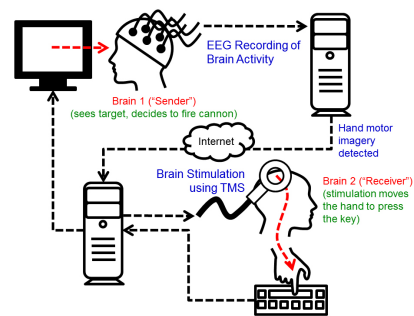
This Gaming Headset Shoots Electricity Into Your Brain. Seriously

... and Less Stylish Devices



High resolution tCS with simultaneous EEG monitoring (available from StarLabs)

... for Future Games



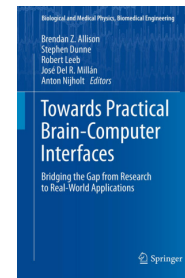
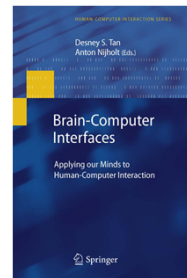
University of Washington

Rao, R.P.N., Stocco, A. (2013) Direct brain-to-brain communication in humans: A pilot study.

Conclusions

- BCI gets more embedded in 'natural' situations and applications
 - Multimodal, Multi-party, MultiBrain
 - MultiBrain BCI has become a research area
- Joint development of serious and entertainment games
- Further development of commercial BCI devices and integration with other devices

MORE TO READ BOOKS



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References

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- A. Nijholt, H. Gürkök. [Multi-Brain Games: Cooperation and Competition](#). In: Proceedings *Universal Access in Human-Computer Interaction. Design Methods, Tools, and Interaction Techniques for einclusion, 7th International Conference, UAHCI 2013*, held as part of HCI International 2013, 15th International Conference on Human-Computer Interaction (HCI International 2013), Las Vegas, Nevada, USA, 21-26 July 2013, UAHCI/HCI 2013, Lecture Notes in Computer Science 8009, C. Stephanidis and M. Antona (Eds.), Springer, Berlin Heidelberg, 2013, 652-661.
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Why Games?

- Why look at BCI in games?
 - Economic importance
 - Games can be designed for health & education & safety & management (serious games)
 - New types of games, new types of users
 - Test ground for BCI for home and professional applications
 - Interesting design challenges: turning shortcomings into game challenges
 - Gamers are early adopters/large market

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MultiBrain: Early History

- **Ecology of the Skin**
 - Rosenboom, 1971, music control, 10 participants
- **Brainwave Drawing Game**
 - Sobel, 1972-1975, superimpose visualized brain wave synchronicity on the image of the two participants
- **Brainwave Etch-a-Sketch**
 - Humbert, 1974, two participants control horizontal or vertical movements of a dot on a screen